

Proposal # **2001- F204** (Office Use Only)

**PSP Cover Sheet** (Attach to the front of each proposal)

Proposal Title: Monitoring and assessing the ecosystem/water quality in the San Francisco/Sacra-

Applicant Name: Minghua Zhang mento-San Joaquin bay-delta-valley region using

Contact Name: Sharon Russell remote sensing and GIS techniques

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Amount of funding requested: \$ 416,446

Some entities charge different costs dependent on the source of the funds. If it is different for state or federal funds list below.

State cost \_\_\_\_\_

Federal cost \_\_\_\_\_

Cost share partners?

\_\_\_\_ Yes X No

Identify partners and amount contributed by each \_\_\_\_\_

Indicate the Topic for which you are applying (check only one box).

- |  |  |
|--|--|
| <input type="checkbox"/> Natural Flow Regimes                | <input type="checkbox"/> Beyond the Riparian Corridor                |
| <input type="checkbox"/> Nonnative Invasive Species          | <input type="checkbox"/> Local Watershed Stewardship                 |
| <input type="checkbox"/> Channel Dynamics/Sediment Transport | <input type="checkbox"/> Environmental Education                     |
| <input type="checkbox"/> Flood Management                    | <input type="checkbox"/> Special Status Species Surveys and Studies  |
| <input type="checkbox"/> Shallow Water Tidal/ Marsh Habitat  | <input type="checkbox"/> Fishery Monitoring, Assessment and Research |
| <input checked="" type="checkbox"/> Contaminants             | <input type="checkbox"/> Fish Screens                                |

What county or counties is the project located in? Sacramento, San Joaquin

What CALFED ecozone is the project located in? See attached list and indicate number. Be as specific as possible 1

Indicate the type of applicant (check only one box):

- |  |   |
|--|---|
| <input type="checkbox"/> State agency                    | <input type="checkbox"/> Federal agency |
| <input type="checkbox"/> Public/Non-profit joint venture | <input type="checkbox"/> Non-profit     |
| <input type="checkbox"/> Local government/district       | <input type="checkbox"/> Tribes         |
| <input checked="" type="checkbox"/> University           | <input type="checkbox"/> Private party  |
| <input type="checkbox"/> Other: _____                    |   |

XX	San Joaquin and East-side Delta tributaries fall-run chinook salmon	
<input type="checkbox"/>	Winter-run chinook salmon	<input type="checkbox"/> Spring-run chinook salmon
<input type="checkbox"/>	Late-fall run chinook salmon	<input type="checkbox"/> Fall-run chinook salmon
<input type="checkbox"/>	Delta smelt	<input type="checkbox"/> Longfin smelt
<input type="checkbox"/>	Splittail	<input type="checkbox"/> Steelhead trout
<input type="checkbox"/>	Green sturgeon	<input type="checkbox"/> Striped bass
<input type="checkbox"/>	White Sturgeon	<input type="checkbox"/> All chinook species
<del>XX</del>	Waterfowl and Shorebirds	<input type="checkbox"/> All anadromous salmonids
<del>XX</del>	Migratory birds	<input type="checkbox"/> American shad
<input type="checkbox"/>	Other listed T/E species: <u>See Table 1 in proposal</u>	

<input checked="" type="checkbox"/> Research/Monitoring	<input type="checkbox"/> Watershed Planning
<input type="checkbox"/> Pilot/Demo Project	<input type="checkbox"/> Education
<input type="checkbox"/> Full-scale Implementation	

If yes, list project title and CALFED number \_\_\_\_\_

If yes, list CVPIA program providing funding, project title and CVPIA number (if applicable):

- The truthfulness of all representations in their proposal;
- The individual signing the form is entitled to submit the application on behalf of the applicant (if the applicant is an entity or organization); and
- The person submitting the application has read and understood the conflict of interest and confidentiality discussion in the PSP (Section 2.4) and waives any and all rights to privacy and confidentiality of the proposal on behalf of the applicant, to the extent as provided in the Section.

Printed name of applicant

Minghua Zhang  
Signature of applicant

## **Title sheet**

**Title:** Monitoring and assessing the ecosystem/water quality in the San Francisco/Sacramento-San Joaquin bay-delta-valley region using remote sensing and GIS techniques

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**Project period:** January 1, 2001 - December 31, 2003

**Requested amount:** \$416,446 Federal Funding

Or \$314,900 State Funding

## **Executive Summary**

Intensive anthropogenic activities in San Francisco/Sacramento-San Joaquin Bay-Delta region have reduced and altered habitat for many important species and affected the ecological integrity and sustainability of the region. These effects are mainly associated with ecosystem/water quality. Ecosystem restoration becomes essential in maintaining sustainability of the region in biodiversity and productivity.

Ecosystem restoration in the region requires comprehensive information on fluctuating environmental conditions, and potential risks to the ecosystem quality. Using the traditional ground point-measurement method to monitor and assess the environmental conditions and ecosystem quality in such a vast region is time-consuming and expensive. However, combining remote sensing and Geographic Information Systems (GIS) analysis provides a new approach for monitoring and assessing environmental conditions and ecosystem quality in the Bay-Delta region.

Remote sensing satellite data can provide insight into environmental conditions and ecosystem quality for the Bay-Delta region. Our Department can combine spectral data and existing GIS databases to derive the information on ecological productivity, biodiversity and biomass productivity, surface moisture variation, and near-surface energy exchange. Then the derived information can be utilized for monitoring and assessing the spatial variations of ecological integrity and sustainability in the region.

A number of remote sensing data and GIS databases on the Bay-Delta region have been acquired and established in last two decades. The objective of the proposed research is to develop methods and procedures by which available remote sensing data and GIS databases can be utilized to monitor and assess environmental conditions and ecosystem quality in the Bay-Delta region.

Environmental/ecological conditions have different spectral characteristics in visible, near infrared and thermal infrared regions of the spectrum. Accordingly, the spectral features retrieved from remote sensing data can be used as indicators for environmental quality and/or other environmental and biological conditions. These conditions include water sediment content, chlorophyll content, and water temperature, as well as ground temperature, soil moisture, heat fluxes, vegetation productivity, biomass, vegetation density, and cover rate. Due to the specific differences of biochemistry, morphology, and canopy structures among the target species (Table 1) in the Delta, these species-specific features can be remotely sensed and target species can be distinguished by the specific biological feature-light responses. Therefore, using multi-band remote sensing data acquired at various seasons, the ecosystem/water quality as well as environmental/ecological conditions in the Bay-Delta region can be assessed and monitored for the target species.

The research approaches are as follows:

(1) Develop algorithms to retrieve environmental features (define environmental features here...) from remote sensing images. The research will develop and test various algorithms for three aspects: estuary water color indicating different environmental conditions; vegetation index

indicating vegetation status, and ground temperature indicating thermal features of the region. We will use several kinds of multi-band remote sensing data covering visible, near infrared and thermal infrared regions of the spectrum. We will utilize various spatial and temporal resolutions. Data sources mainly include NOAA-AVHRR, Landsat TM, and other airborne images.

(2) Retrieve the required ground truth measurements from the available GIS databases. These measurements will be used for determining the relationship between the remotely sensed reflectance and the biological features in the regions. The GIS databases will guide us in designing the ground truth locations and measurements. The database will provide a validation for the relationship between the remotely sensed image and the biological/ecological features on the surface. About 20 sites representing various ecosystem patterns and environmental/ecological conditions in the Bay-Delta region will be selected for ground truthing measurements. Important environmental conditions and the site-specific condition of biology and ecology of the target species will also be measured/observed at each sites during the project period.

(3) Determine relationships between remote sensing-based spectral properties/features and environmental/ecological conditions as indicated in the ground truth measurement data. These relationships are used to monitor and assess ecosystem/water quality and ecological/environmental conditions of the Bay-Delta region for the target species.

The geographic scope of our research would include the whole region of CALFED Bay-Delta Program, although we would focus more on the ecological zone of the region (Fig. 1). This research would have no adverse impacts on any third parties.

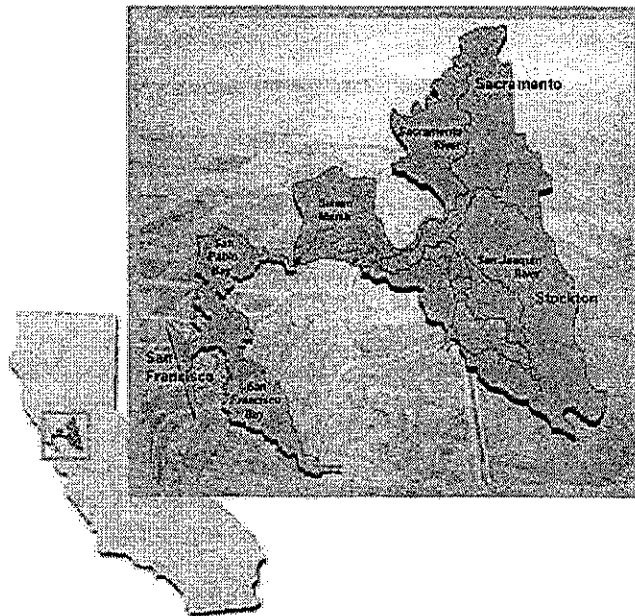


Figure 1. Geographic Location of the Bay Delta Region for the proposed research

**Applicability to CALFED goals:** The proposed research will be applicable to the first and the third general objectives of the CALFED Bay-Delta Programs, i.e. ecosystem quality and water quality. Using remote sensing and GIS, our proposed research intends to monitor and assess the environmental/ecological conditions and ecosystem/water quality of the region for the target

species. Based on the monitoring and assessment, actions can be formulated and implemented to improve and increase ecological functions and water quality in the bay-delta region.

Our project will provide critical information needed for improving ecosystem water quality. This information will be presented in a manner that is easily comprehensible to scientists of multiple disciplines, and to non-scientists who must make difficult decisions affecting land use and restoration projects. In addition, this project proposes to utilize the state-of-the-art technologies in monitoring and assessing ecosystem/water quality. These technologies will inevitably become a major part of monitoring and assessing the ecosystem quality on a timely basis in the near future.

The specific tasks and expected results from this project can be grouped into following aspects: (1) Develop remote sensing and GIS-based methods and procedures for monitoring and assessing the ecosystem/water quality and ecological/environmental conditions in the Bay-Delta region. These methods and procedures may also be applicable to the other delta regions; (2) Map important environmental/ecological conditions in the Bay-Delta region for evaluation and description of their spatial variation and temporal dynamics. For the terrestrial domain, this will generate images showing vegetation productivity, biomass, vegetation cover rate and density, vegetation index, ground surface temperature, heat fluxes, soil moisture and evaporation rate, etc. For the aquatic domain, images will show coastal sediment content, chlorophyll concentration, water temperature, and evaporation rate; (3) Provide a comprehensive assessment to the ecosystem/water quality and ecological/environmental conditions for the target species in the Bay-Delta region.

Table 1. Target species we will use to select priority monitoring sites for exposure and effects of toxic contaminants in the study area. These species were listed in ERP, Volume I, pages 178-179.

Species	Priority level in CALFED ERP
Suisun thistle	Priority Group II species
soft bird's-beak	Priority Group II species
Mason's lilaeopsis	Priority Group II species
Delta button-celery	Priority Group II species
California tiger salamander	Priority Group III species
Native anuran amphibians	Priority Group III species
Western spadefoot toad	Priority Group III species
California red-legged frog	Priority Group III species
Giant garter snake	Priority Group III species
Western pond turtle	Priority Group III species
Swainson's hawk	Priority Group II species
California clapper rail	Priority Group II species
California black rail	Priority Group II species
Greater sandhill crane	Priority Group III species
Western yellow-billed cuckoo	Priority Group III species
Bank swallow	Priority Group III species
Suisun song sparrow	Priority Group II species
Western least bittern	Priority Group III species
Least Bell's vireo	Priority Group III species
Little willow flycatcher	Priority Group III species
Salt marsh harvest mouse	Priority Group II species
San Pablo California vole	Priority Group II species
Suisun ornate shrew	Priority Group II species
Riparian brush rabbit	Priority Group III species
San Joaquin Valley woodrat	Priority Group III species
Valley elderberry longhorn beetle	Priority Group II species

## Overall Description of the project

### **Monitoring and assessing the ecosystem/water quality in the San Francisco/Sacramento-San Joaquin bay-delta-valley region using remote sensing and GIS techniques**

#### **1. Objectives and background**

San Francisco/Sacramento-San Joaquin Bay-Delta-valley region (hereafter Bay-Delta region or “the region”, Fig. 1) has developed into one of the most populated areas, and extremely important economic region, in the western coast of the United States (French 1999). This is partially because the region possesses its location convenience/advantages as well as abundant natural resources especially the fertile land. However, intensive anthropogenic activities have dramatically changed the natural environment and ecological conditions in the region (Carriquiry and Sanchez 1999, Meyer and Turner 1992). Agricultural activities have contaminated the Sacramento River, the San Joaquin River and the Delta with pesticides and nitrates (Zhang et al. 1999, 1998 and 1997, Geng et al. 1995). Soil erosion has been aggravated due to the various human actions. Millions tons of waste water with suspended sediments and other toxic materials from cities, towns and settlements are pouring into the bay, delta, and the rivers of the region. Dust and waste gases are emitted into the air. All these forms of pollution are impacting the environmental/ecological conditions of many important species, threatening the ecological integrity and sustainability (Zeidler 1997, Williams 1990) of the region.

Therefore, assessing and monitoring environmental and ecological conditions of the whole Bay-Delta region are very important in maintaining the sustainability of the region. From our assessments and monitoring we can formulate policies, and implement conservation programs to protect and restore habitats and ecosystems. We can work to improve the conditions for a better environment, and to achieve sustainable development in the region (French 1999).

The environmental conditions and ecosystem/water quality of the region can be measured and assessed through several factors. In the coastal water, for example, water quality is generally measured using sediment loading, chlorophyll and other nutrient contents, algae contents, pollution content, aquatic plant and animal density, water reflectance, water temperature, surface sensible heat flux, and surface evaporation. These variables also have an intimate relationship with the animal and vegetation communities that make up the estuary ecosystem (French 1999), thus, they also serve as important factors indicating the ecosystem quality of the Bay-Delta region.

Conventionally, estuary environmental conditions and relevant ecosystem/water quality are assessed and monitored through ground point measurement for the important variables. In addition, spatial variation in assessment indicators is generally difficult to derive using point sampling. For a vast area such as the Bay-Delta region, conventional assessment methods, although direct, are costly and time-consuming (Phinn et al. 1999). The successful assessment strongly depends on the number of sampling points, their location, and their spatial distribution.



Many measurements on specific points may not be sufficient to accurately characterize the whole region. Remote sensing combined with GIS provides a new approach of remotely assessing and monitoring temporal and spatial variations of the estuary environment and ecosystem quality (Phinn et al. 1999, Li et al. 1998, Donoghue et al. 1994). The spectral features of estuary environments not only directly reflect its quality and/or conditions but also relate to its ecological productivity, vegetation diversity and biomass density, surface moisture variation, and near-surface energy exchange, that represent the status of its ecological integrity and sustainability. Using multi-band remote sensing systems mounted on satellites and airplanes, spectral features of the whole estuary region can be simultaneously observed at a regular time basis. Based on the spectral features retrieved from remote sensing data, we will develop many important environmental indicators such as sediment content, vegetation index, soil moisture content, and surface temperature. These indicators can be used to quantitatively assess and monitor environmental quality and/or conditions, ecological integrity, and sustainability in the San Francisco/Sacramento-San Joaquin Bay-Delta region.

With the development of remote sensing technology, many digital images of the Bay-Delta region have been acquired in the last 20 years. Several GIS databases, such as the AGIS (Agricultural GIS) database at our Department have also been established. The AGIS database contains a great volume of environmental and ecological data on the Bay-Delta region.

The primary objective of the proposed research is to develop a methodology for monitoring and provide spatial overview for assessing the ecosystem/water quality. The methodology will enable us to use available remote sensing data and GIS databases to monitor environmental conditions and ecosystems/water quality in the Bay-Delta region for the target species (Table 1). The spatial map overview of various parameters in ecosystem/water quality will allow us to understand the current distributions and variations of each parameters considered in ecosystem/water quality and evaluate the system sustainability. We expect that the results can provide a quick and novel methodology of utilizing remote sensing and GIS to monitor and assess the ecosystem/water quality for the region, but also provide the information for regulation and education.

In the recent years, remote sensing has been extensively applied in many geophysical studies. However, using remote sensing to study estuarine environments and ecological dynamics remains a neglected compared with other remote sensing applications (Cracknell 1999 and 1989). Current remote sensing studies of estuarine environment concentrate mainly on geological and geomorphological dynamics (Krishnan 1997, Dalrymple et al. 1995), and coastal current patterns (Frasier et al. 1998, Gallaudet and Simpson 1994). In California, there are few remote sensing studies of estuarine ecosystems. Using the approach of combining remote sensing with field sampling, Zhang et al. (1997), we developed methods for evaluating the conditions of salt marsh ecosystems. Relationships between vegetation indices retrieved from Landsat TM data and canopy biomass have been formulated and validated for the entrance of the Petaluma River into San Pablo Bay (Zhang et al. 1997). In another study, we estimated canopy water content using AVIRIS data, and developed a water content index for determining patterns of canopy water content at different spatial extents (Sanderson et al. 1998). Phinn et al. (1999) studied vegetation structural characteristics in restored wetlands of southern California using hand-held and airborne remotely sensed data. Parameters such as stem length, density, and canopy

architecture of cordgrass has been correlated to vegetation index values computed from their data. In another study, Phinn et al. (1996) examined the wetland habitat restoration in southern California using airborne multispectral video data. Deysher (1993) used SPOT image to map the giant kelp along the California coast. Other relevant studies in the region include Townshend and Tucker (1984), Khorram (1981, 1982) and Colwell (1979). Townshend and Tucker (1984) demonstrated the applicability of AVHRR and MSS data to land cover mapping in the Imperial Valley. Khorram (1981 and 1982) used MSS and U-2 aerial photograph to assess turbidity and suspended solids as well as salinity within the San Francisco Bay-Delta.

It seems that the recent studies on the remote sensing of estuarine environment and ecological conditions are not very active in the San Francisco/Sacramento-San Joaquin Bay-Delta region. The existing studies are oriented to the use of visible and NIR channels for sediment and biomass assessments. Thermal satellite imagery data has not yet been applied to assess thermal properties of estuarine environments, nor has it been used to assess or monitor ecosystem/water quality of the region. Furthermore, mutual relations among the sediments, suspended solids, biomass, thermal properties, and other important factors in the estuarine ecosystems have not been systematically investigated in the Bay-Delta region.

Ecologically and environmentally, the Bay-Delta region is an integrated estuarine system. Our research will develop and validate various methods and procedures to extract useful information for assessing environmental conditions and ecological integrity of estuarine ecosystems. Based on the spectral features from remote sensing and ground truth data extracted from available GIS databases, we will systematically investigate the mutual relationships among retrieved spectral features and the important environmental conditions of the whole Bay-Delta region. We will therefore be combining indices of vegetation surface temperature, and other retrieved data to determine such important environmental conditions as erosion intensity, evapotranspiration, and hydrological properties.

Our research will provide critical information needed for improving ecosystem/water quality. This information will be presented in a manner that is easily comprehensible to scientists of multiple disciplines, and to non-scientists who must make difficult decisions affecting land use and restoration projects.

## **2. Approaches**

In order to achieve the objectives of monitoring and assessing ecosystem/water quality from remote sensing data in the Bay-Delta region, our research will adopt the following general approaches and specific analysis methods:

### **2.1 General approaches of the proposed research**

- (1) Identify and extract the required spectral features from remote sensing data;
- (2) Derive ground truth data from available GIS databases;
- (3) Combine spectral features with ground truth data to establish relationships between the extracted features and the important environmental indicators of the estuarine ecosystems in the region;
- (4) Apply these relationships, after testing their applicability to the region, to estimate the spatial variation of important environmental indicators from the available remote sensing data.

The essential spectral features required to extract in the research are as follows:

- (1) Sediment index for estimating sediment content and assessing estuary water quality in the region;
- (2) Vegetation index directly relating chlorophyll content/ water quality and vegetation status in the region;
- (3) Surface temperature index of the thermal properties of region.

Based on these spectral features, the following important conditions in the region can be estimated according to their direct relations or indirect correlation. (1) biomass, vegetation cover rate, biomass density, and vegetation productivity in each watersheds in the region; (2) chlorophyll content and relevant nutrients in the bay water; (3) sediment content and pollutant contents in the bay water; (4) erosion intensity of the region; (5) surface moisture and related hydrological parameters; (6) heat fluxes, evaporation, and other related thermal parameters. Our research will develop the methods and procedures for determining these environmental conditions from remote sensing, as well as for validating these relationships and correlation in the Bay-Delta region.

## **2.2 Remote sensing analysis for retrieving spectral features**

Remote sensing data used in the research includes various satellite images (mainly Landsat TM, NOAA-AVHRR and MODIS) and aerial photographs such as AVIRIS. Since the acquisition of remote sensing data unavoidably involves the effects of atmospheric and geographic distortion, radiometric and geometric corrections have performed before spectral feature extraction (Thome et al. 1997, Gao et al. 1993, Weinreb et al. 1990). Since the approaches for radiometric and geometric corrections are very basic in remote sensing image processing, we don't want to discuss them in detail. Instead, the emphasis in the following section is given to the important methods used for spectral feature extraction.

### **2.2.1. Method for assessing water quality in remote sensing**

A spectral index will be developed to indicate water quality in the region. High quality or pure water has very low spectral reflectance. It only reflects some blue light and almost absorbs the radiance in green, red and near infrared regions. As impurities (mainly sediments) are added to a water body, its spectral properties change (Anji Reddy 1993, Gao and O'Leary 1997). In remote sensing, pure water acts as a "dark" object with low digital number (DN) in visible spectrum. As sediment content increases, the brightness of water in the visible spectrum increases. Therefore, using the color of estuarine water in visible channels of remote sensing data, we can develop an index to retrieve the spectral signal relating to sediment content in the water. After calibrating with the pure water body nearby and combining results with available GIS databases, water sediment content can be estimated.

### **2.2.2 Method for assessing chlorophyll content and vegetation status in the region**

Chlorophyll in living vegetation absorbs red light, showing a high reflectance in the NIR spectrum. This spectral characteristic has been extensively used to develop vegetation indices for remote sensing of vegetation (Ustin et al. 1993).

Usually a vegetation index is formed from combinations of several spectral values that are added, divided or multiplied in a manner designed to yield a single value that indicates the

amount of vegetation within a pixel scale (Campbell 1996). To this date, at least 40 vegetation indices have been developed. The simplest is the ratio between the IR and R bands i.e. IR/R, where R refers to red light and IR infrared. The most widely used vegetation indices probably is the normalized difference vegetation index (NDVI):

$$NDVI = (IR - R) / (IR + R)$$

For Landsat TM, IR and R are TM3 (630-690nm) and TM4 (760-900nm) respectively. For NOAA-AVHRR, IR and R are channel 2 and 1 in 725-1100nm and 580-680nm regions.

After a vegetation index is computed, we will correlate it to ground truth data and the available GIS databases to determine the biological properties of the plants in the region. Several empirical relationships between vegetation index values and biomass and vegetation water content have been used for agricultural crops (Campbell 1996; Zhang et al. (1997). We also developed several methods for determining relationships for Landsat TM in the estuarine ecosystem of Petaluma River entrance into San Pablo Bay, California. Phinn et al. (1999) studied the relationships for hand-held and airborne remotely sensed data in restored wetlands of south California. The relationships in the Bay-Delta region, and for other remote sensing data such as AVHRR and MODIS, have not yet been reported. We will study the relationships for the available remote sensing data, and test them in the several different estuarine ecosystems of our region.

Based on vegetation index, the following important indicators will be derived in this research.

- (1). Chlorophyll content in the bay water as is directly related to the vegetation index of the water body.
- (2) Vegetation cover rate in pixel scale can be computed as  $VCR = (VI - VI_s) / (VI_v - VI_s)$ , in which  $VI_s$  and  $VI_v$  are vegetation index value for bare soil and a full vegetation cover.
- (3) Biomass of the region directly correlates to the value of vegetation index.
- (4) Biomass density relates to biomass and the pixel size.
- (5) Vegetation productivity relates to the value changes of vegetation index in the growing period.

### 2.2.3 Method for ground surface temperature retrieval from NOAA-AVHRR data

Temperature is an important environmental indicator relating to the ecosystem/water quality in the region. The retrieval of surface temperature from NOAA-AVHRR data is achieved mainly through the application of split window algorithm [Qin and Karnieli 1999, Vogt 1996]. If  $T_4$  and  $T_5$  are respectively the brightness temperatures in channels 4 and 5 of AVHRR data, which are given by inverting Planck's equation for the radiation received by the sensor, the general form of split window equation can be expressed as

$$T_s = T_4 + A(T_4 - T_5) + B$$

where  $T_s$  represents land surface temperature,  $A$  and  $B$  are the coefficients affected by the atmospheric transmittance and surface emissivity in channel 4 and 5 of NOAA-AVHRR.

Split window technique was firstly developed for estimation of sea surface temperature (SST) from AVHRR data (Prabhakara et al. 1974; McMillion 1975; Deschamps and Phulpin 1980; McClain et al. 1984; Barton 1992). Price (1984) is one of the pioneers applying split window technique to land surface temperature (LST) retrieval. Considering the mixed surface composition in the region, the LST algorithm is better than the SST one for estimating the thermal properties of the estuarine ecosystems.

Several modifications to the method of Price (1984) have been published since mid-1980s. The existing methods can be grouped into two categories. **Category 1** are those that require not only the transmittance and emissivity but also one or two other parameters, which are usually difficult to estimate in most cases due to the lack of *in situ* atmospheric profiles. Such methods include Coll and Caselles (1994), Sobrino et al. (1991), Franca and Cracknell (1994), Prata (1993), etc. **Category 2** are those that assume the effect of transmittance as constant, that is not true in the real world, and only emphasize the effect of emissivity on LST retrieval, such as Price (1984) and Becker and Li (1990) etc. A better split window algorithm that requires only the two essential parameters has been proposed in Qin *et al.* (in press a). The algorithm has the form as follows:

$$T_s = A_0 + A_1 T_4 - A_2 T_5$$

where the coefficients  $A_0$ ,  $A_1$  and  $A_2$  are defined as

$$\begin{aligned} A_0 &= E_1 a_4 - E_2 a_5 - E_3 (a_4 - a_5) & A_1 &= 1 + A + (E_1 - E_3) b_4 & A_2 &= A + (E_2 - E_3) b_5 \\ E_0 &= D_5 D_4 - D_4 D_5 & E_1 &= D_5 (1 - C_4) / E_0 & E_2 &= D_4 (1 - C_5) / E_0, \\ E_3 &= D_4 D_5 / E_0 & C_i &= \varepsilon_i \tau_i(\theta) & D_i &= (1 - \tau_i(\theta)) [1 + (1 - \varepsilon_i) \tau_i(\theta)] \end{aligned}$$

The constants are given as  $a_4 = -65.51625$ ,  $a_5 = -70.003$ ,  $b_4 = 0.44184$  and  $b_5 = 0.47571$  (Qin *et al.* in press a).

Due to lack of *in situ* atmospheric profile observation, we will mainly base on the algorithm of Qin *et al.* (in press a) in the proposed research to develop a proper procedure for retrieving the thermal properties of the estuarine environments in the bay-delta region from AVHRR data. This includes (1) to estimate the coefficients of the algorithm for the estuarine in our study region and (2) to relate the retrieved thermal features from AVHRR data with other environmental conditions in the region.

#### 2.2.4 Method for ground surface temperature retrieval from Landsat TM data

The Landsat Thematic Mapper (TM) has a thermal band (channel 6) operating in the wavelength range of 10.45-12.50  $\mu\text{m}$  with a nominal ground resolution of 120  $\times$  120m. This spatial resolution is high enough for analyzing the detailed spatial patterns of thermal variation in the estuarine environments. Based on the thermal radiance transfer equation, Qin *et al.* (in press b) developed a mono-window algorithm for retrieving LST from Landsat TM thermal data. The algorithm has the following form:

$$T_s = [a_6(1 - C_6 - D_6) + (b_6(1 - C_6 - D_6) + C_6 + D_6)T_a - D_6 T_a] / C_6 \quad (18)$$

Where  $C_6 = \varepsilon_6 \tau_6$ ,  $D_6 = (1 - \tau_6) [1 + (1 - \varepsilon_6) \tau_6]$ ,  $a_6$  and  $b_6$  are constants given as  $a_6 = -67.37104$  and  $b_6 = 0.45866$ ,  $T_a$  is effective mean atmospheric temperature, which can be estimated from surface air temperature [Qin *et al.*, in press b]. In the proposed research, we will base on this algorithm to develop a proper procedure for retrieving thermal properties from Landsat TM data.

#### 2.3 Ground truth data

The retrieved spectral features from remote sensing data have to be connected to the real environmental/ecological factors in the region. This implied that the relationship between the retrieved spectral features and the ground truth data have to be determined and validated.

One alternative to our research is to collect new field data. However, this would be very costly and time-consuming. Actually, most of the required ground truth data are available in the GIS databases of our Department and multiple government agencies. The University California at

Davis, for example, has a meteorological database storing detailed meteorological observation data of about 350 stations in California and many USGS gaging stations. The AGIS laboratory of the Department led by the applicant Dr. Zhang already establishes several GIS databases of the region. These available databases together with scientific literature and government reports can provide almost the required ground truth data for the research. Specially, about 20-30 sites representing various patterns of ecosystems in the bay-delta region will be given intensive examination in the research. Information about the environmental conditions, vegetation status, thermal properties and surface spectrum of the sites will be collected at the sites during the project period.

#### **2.4 Correlate the retrieved spectral features to ground truth data**

The ground truth data will be used to correlate with the retrieved spectral features from remote sensing data as well as to validate the applicability of the established correlation for monitoring and assessing the ecosystem/water quality in the region.

Methods used in the correlation include both empirical techniques and simulation modeling. The empirical way is to correlate the retrieved spectral features (one or more) to the ground truth data to form their regression equations. When the equation has a significant correlation statistically, it can be used for the estimation. The amount of vegetation productivity is an important environmental parameter relating to carbon cycling and photosynthesis process of ecosystem. Several empirical methods for determining primary productivity from remote sensing data have been reviewed in Dedier (1996). Simulation modeling is to use the interrelated relations among many variables in the ecosystem to estimate the unknowns through the system's model (Yang and Sykes 1999). The well-known model is surface energy model for sensible heat flux, evaporation and other thermal property estimation (Caselles et al. 1998, Kaneko 1996, Norman et al. 1994, Seguin 1994, Choudhury 1989). Other models include watershed hydrological model for estimating the hydrological process and parameters, water-energy-carbon model for estimating photosynthesis and biogeochemistry processes of ecosystem (Olioso 1995, Sellers et al. 1994).

Both the two methods (correlation and modeling) will be used in the research. Though several equations have been proposed for specific cases (Zhang et al. 1997, Phinn et al. 1999), their coefficients and parameters need to be determined in the research according to the situations in the bay-delta region.

### **3. Expected results or benefits**

Our proposed research would contribute to the goals and objectives of the CALFED Ecosystem Restoration Project and Program, described in chapter 1. Several academic innovations will be resulted from the proposed research. The expected results and benefits of the research can be summarized as follows:

**(1) Developed methodologies and procedures based on remote sensing and GIS** for timely monitoring and assessing the ecological/environmental conditions, water quality, vegetation status, thermal properties and surface parameters that indicate the integrity and sustainability of the estuarine ecosystems in the bay-delta region. These methods and procedures may also be applicable to other regions in the States.

Environmental and ecological issues of estuarine have been studied from conventional approaches based on ground point measurements (Harrop and Nixon 1999, Mathieson and Nienhuis 1991). The development of remote sensing and GIS techniques makes it great potential in estuary and coastal studies (Cracknell 1999 and 1989). However, the study of estuarine environmental conditions and ecological integrity from remote sensing still remains as a neglected area compared with the extensive application of remote sensing to other areas. According to publications of the 28<sup>th</sup> Estuarine and Coastal Sciences Association Symposium, the remote sensing of coast and estuaries focused on water bathymetry, coastal and sub-water landscape process, water current patterns (McManus et al. 1999, Sandidge and Holyer 1998). The estuarine environmental and ecological issues in the bay-delta region and the Pacific Coast of the States have not been extensively studied from remote sensing. Studies of estuarine ecosystem/water quality from remote sensing and GIS still have not been reported in the region. And the proposed research intends to give an effort on this aspect.

**(2) Developed algorithms and procedures** of specific biological/ecological features and light responses for retrieving important environmental features from remote sensing data. The algorithms mainly including those for coastal water color mapping, algorithms for vegetation signal retrieval and algorithms for ground surface temperature and thermal features retrieval, and procedures combined with vegetation signal and ground temperature for vegetation status estimation.

Retrieval of spectral features from remote sensing data for environmental studies has been extensively investigated in many landscapes and geographic regions. In estuarine, some studies also have been conducted for spectral features retrieval from remote sensing data (Braga et al. 1993, Zhang et al. 1997, Phinn et al. 1999 and 1996). Difference procedures and algorithms are developed and validate for different surface conditions. Systematic development of the algorithms and procedures for the whole estuarine aquatic and terrestrial domains as an interrelated ecosystem in the bay-delta region of California has not been reported. In the proposed research, we will systematically develop the algorithms and procedures for retrieving the required spectral features from available remote sensing data and validate these algorithms and procedures using the field sampling data taken from various ecosystem patterns in the region. The concentration in this aspect is to estimate the proper coefficients suitable for the estuarine conditions of the region.

Another important focus is to establish the relationship between the spectral features and the ground truth data for estimating the important environmental/ecological conditions in the region in terms of viewing the whole bay-delta region as an integrated ecosystem, using statistical correlation method and/or simulation modeling. In the existing studies, only some of the relationships about vegetation status have not been reported while leaving many such as thermal properties unknown.

**(3) Monitoring and assessing the ecosystem/water quality of the region.** In the research we intend to generate a number of maps and images showing vegetation productivity, biomass, vegetation cover rate and density, vegetation index, ground surface temperature, heat fluxes, soil moisture and evaporation rate, coastal sediment content, chlorophyll concentration, water temperature and evaporation rate. Based on these maps and images, a comprehensive assessment

will be given to the ecosystem/water quality of the bay-delta region for the target species. Activities can be formulated to fulfill the goals of CALFED Ecosystem Restoration Program.

As mentioned above, remote sensing observing the ground from space with frequent temporal coverage provides the spatial spectral information about the ground. Monitoring and assessing the environmental/ecological conditions from remote sensing data overcomes the shortages of the conventional method based on point measurement. Except the spatial instantaneously investigation, it can provide serial change of the environmental/ecological conditions at various seasons of the year, even monthly, weekly or days. Such time series monitoring enables the study of estuarine environmental dynamics for effective restoration activities to improve and increase ecosystem/water quality of the region, which is the general goal of the CALFED Ecosystem Restoration Program.

#### **4. Work plan and time table**

The proposed research will be completed in **three years**. Details of work plan for each year are described as follows:

**In 2001**, the first half will be used to prepare the required conditions for the research, including (1) Design the detailed work steps, research framework and approaches. (2) Organize the research team and organize field tours to various ecosystem patterns of the region. (3) Collect the available data and relevant reports from various sources and agencies.

The second half of 2001 will be used to (1) Set up the intensive study sites and start the collect information about the environmental/ecological conditions of the sites. (2) Obtain the remote sensing data. (3) Develop procedures and standards for processing remote sensing data. (4) Conduct remote sensing data processing. We expect to produce two reports/articles by the end of the first year.

**In 2002**, the main work will be (1) to obtain/derived the ground truth data from physical sampling sites and/or from available GIS databases. (2) to obtain the required remote sensing images. (3) to process the available remote sensing data. (4) to analyze the relationship between ground truth data and the spectral features retrieved from remote sensing data. We expect to produce three research reports/articles by the end of second year.

**In 2003**, the first half year will be used to continue the main research work in previous years, including GIS database and remote sensing analysis. However, the focus will be given to the development and validation of methods and procedures used to assess and monitor the environmental/ecological conditions and ecosystem/water quality of the bay-delta region. Specifically, the relationships between the spectral features from remote sensing data and the important environmental/ecological conditions will be established during the period, using the ground truth data in the last two years. This also includes the validation of the proposed methods and procedures. Then, the methods and the procedures will be used to generate the images/maps indicating the spatial variation of several important environmental/ecological conditions, resulted from processing the available remote sensing data on the basis of the ground truth measurements.



The second half year will be used to prepare the final report of the research. The report will include the results of the research and suggestions of the outreach and result dissemination to the agencies and the public. We expect to exchange the information with relevant scientists from CALFED agencies and other institutions and expect to improve the report and re-check the results by receiving the feedback from peers. We also expect to present the final results to the consortium of CALFED Ecosystem Restoration Program and other outreach organizations. We plan to provide seminars to the public about the research results and would like to publish the results in scientific journals.

## **5. Applicant Qualifications**

Dr. Minghua Zhang will lead the proposed project. Dr. Zhang earned her Ph.D. in ecology from University of California at Davis in 1993. Currently she leads the Agricultural Geographical Information System (AGIS) laboratory in the Department of Land, Air, and Water Resources, University of California at Davis. Her research experiences and teaching interests includes remote sensing application to hydrology and agriculture, geographic information system (GIS) database development, spatial analysis of watershed hydrology using GIS and remote sensing, environmental analysis with GIS, wetland ecology. She has published 22 professional papers, 13 of which were peer-reviewed. She has the experiences in leading successful projects. Currently she holds the membership of the ecology and hydrology graduate programs at UC Davis and supervises seven students, postdoctoral researchers and post graduate researchers in AGIS lab. She teaches the course titled "Environmental Risk Analysis Using GIS" at UC Davis. Currently, AGIS developed a spatial database to query and retrieve pesticide use report records on any built in fields. This database can facilitate the spatial modeling development in environmental risk assessment. She also works as a GIS specialist in the function of Environmental Fate and Risk Assessment at Zeneca Ag Products, which is a leading agrochemical company. Her work responsibility at Zeneca Ag Products included technical consultations on pesticide surface water runoff and groundwater leaching and research of product stewardship for Zeneca products. One of her students is working on developing a spatial model for predicting pesticide residue in surface water systems at a watershed level and understanding the scaling effects on pesticide surface water runoffs.

As project leader, Dr. Zhang has the full responsibility of the research. She will report the accomplishment of the research, respond to any questions from the contacts and submit the final results to the consortium of CALFED Bay-Delta Program.

**Dr. Zhihao Qin** will be the principle researcher for this project. Dr. Qin earned his Ph.D. in remote sensing and GIS from Ben Gurion University, Israel in 1999. He was the associate research professor of the Chinese Academy of Agricultural Sciences, China. He has solid research experiences in remote sensing application, agricultural development and natural resource assessments. His tasks in the research include (1) Conduct GIS analysis and extract the required ground truth data from the available databases. (2) Develop methods and procedures for remote sensing image processing to retrieve the required spectral features. (3) Study the relationship between these spectral features and the key environmental/ecological conditions in the bay-delta region. (4) Combine remote sensing data with GIS methods to monitor and assess the ecosystem/water quality in the region. (5) Prepare reports/articles from the research results dissemination and outreach.

**Dr. Eliska Rejmankova** is a professor in wetland ecology, Department of Environmental Science and Policy, University of California, Davis. She obtained his Ph.D. in botany in 1981 from Czechoslovak Academy of Sciences, CA 95616. Her current research interests are in wetland ecology and environmental issues, life history strategies of wetland plants, water quality improvement of agricultural and urban runoff, conservation ecology, ecotoxicology, systems and landscape ecology. She teaches three courses in wetland ecology for both graduate and undergraduate students at the university. She has published a number of articles on wetland ecology and botany. Her responsibility in the project is to provide the technical advice and inputs to the project design and data analysis from the viewpoints of wetland ecosystem and environmental/ecological issues.

**Dr. Shu Geng** is a professor at the Department of Agronomy and Range Science, University of California, Davis. His research interests include agricultural systems, modeling and simulation of environmental impacts on agricultural production and food systems, productivity and risk assessment, quantitative methodologies and bioinformatics. Dr. Shu Geng teaches biostatistics and computer courses for both undergraduate and graduate levels. He has wide range of international and national collaboration experience and he leads successful research projects. His responsibility in this project is to provide technical advice in designing the project and selecting the appropriate quantitative methodologies for the assessment.

## **6. Technical feasibility**

The Department of Land, Air and Water Resources has excellent facilities supporting the GIS and remote sensing analysis required by the research. It operates an extensive cluster of modern computer workstations including a 4-processor SGI Origin 200, 5 Digital Alphas, 2 SGI Iris's, a Sun Sparcstations and 3 VaxStations. These systems are fully networked and supported by 100GB fixed disks as well as magneto-optical and writeable CDROM disks and 8 mm tape drives. This system is linked with over 30 personal computers and various postscript printer devices. In addition the system is connected to a HP desktop scanner (ScanJet 4C), a Kodak DC 210 Digital Camera and a 33.3 kbps fax/modem. The system also has a Snappy frame grabber which is connected to a Sony VHS video recorder to gather video input. Also available is an 8mm Sony camera/VCR, Panasonic color TV/monitor, Sony VHS VCR and recently purchased Epson Video Projector.

The programs available in the computer systems of the Department includes geographic information system package (ARC/INFO, ArcView and GRASS), remote sensing image processing package (ENVI, IPW, PCI, Khoros), mathematical software (IDL, Mathematica, MATLAB, SAS, Statistica) and atmospheric profile modeling software (LOWTRAN and MODTRAN). These programs provide the analysis tools for the proposed research.

The AGIS laboratory (led by the project leader Dr. Zhang) and the Department have accumulated a number of satellite images and several GIS databases of the bay-delta region, including Landsat TM, NOAA-AVHRR archive and airborne AVIRIS photographs. A number of digital maps such as soil map, drainage system, vegetation maps are available in the Department. We also have many basic hydrological, ecological and environmental data about the region. These data can be used for the research.

The University of California has a weather database storing both current and historical daily weather data for approximately 350 weather stations throughout California. The database contains the very detailed data for a number of meteorological variables such as air temperature, humidity, wind speed and direction, solar radiation, soil temperature, pan evaporation and so on. We can access the database and download the necessary data for the research.

Our study methods would not conflict with any CEQA, NEPA, or other environmental compliance documents. We anticipate using existing data and in not manipulating the environment in any way during the course of the study. However, we will conduct some additional searches for certain target species, and in so doing, we will obtain and use all the survey protocols supplied by the California Department of Fish and Game and U.S. Fish and Wildlife Service.

Our team has the expertise in remote sensing, GIS analysis, wetland and estuary environment and ecosystem, water quality, quantitative methodologies and risk assessment. The research team includes the collaborators from UC Davis and state agencies such as the California Department of Pesticide Regulation and California Department of Food and Agriculture. We have an excellent collaborative research team to assure in carrying out a successful project.

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Monitoring and assessing the ecosystem/water quality in the San Francisco/Sacramento-San Joaquin bay-delta-valley region using remote sensing and GIS techniques												
Budget Proposal: Federal Funding				Subject to Overhead					Exempt from Overhead			
Year	Task	Direct Labor Hours	Salary	Benefits	Travel	Supplies & Expendables	Service Contracts	Overhead (46.5; 48; 48.5)	Equipment	Graduate Student Fee Remission	Total Cost	
Jan-Dec	Task 1	522	\$8,804	\$1,645	\$1,000			\$12,613		\$4,314	\$28,376	
	Subtask 1a	131	\$2,201	\$411							\$2,612	
	Subtask 1b	131	\$2,201	\$411							\$2,612	
	Subtask 1c	522	\$8,804	\$1,645							\$10,449	
	Task 2	522	\$8,804	\$1,645	\$1,000			\$17,499	\$89,000		\$117,949	
	Subtask 2a	261	\$4,402	\$843							\$5,245	
	Subtask 2b	522	\$8,804	\$1,685							\$10,489	
	Subtask 2c	522	\$8,804	\$1,645							\$10,449	
	Project Management	208									\$0	
Total Cost Year 1: 2001			\$52,824	\$9,933	\$2,000	\$0	\$0	\$30,112	\$89,000	\$4,314	\$188,182	
Jan-Dec	Task 1	783	\$13,347	\$2,470				\$30,398		\$4,400	\$50,615	
	Subtask 1a	261	\$4,449	\$844							\$5,293	
	Subtask 1b	522	\$8,898	\$1,688							\$10,586	
	Subtask 1c	1566	\$26,693	\$4,940							\$31,633	
	Project Management	208									\$0	
Total Cost Year 2: 2002			\$53,387	\$9,942	\$0	\$0	\$0	\$30,398	\$0	\$4,400	\$98,127	
Jan-Dec	Task 1	1566	\$28,572	\$5,340				\$41,037		\$4,488	\$79,437	
	Task 2	1566	\$28,572	\$21,128	\$1,000						\$50,700	
	Project Management	208									\$0	
Total Cost Year 3: 2003			\$57,144	\$26,467	\$1,000	\$0	\$0	\$41,037	\$0	\$4,488	\$130,136	
Total Project Cost			\$163,355	\$46,342	\$3,000	\$0	\$0	\$101,546	\$89,000	\$13,203	\$416,446	

Monitoring and assessing the ecosystem/water quality in the San Francisco/Sacramento-San Joaquin bay-delta-valley region using remote sensing and GIS techniques												
Budget Proposal: State Funding				Subject to Overhead								
Year	Task	Direct Labor Hours	Salary	Benefits	Travel	Supplies & Expendables	Service Contracts	Equipment	Graduate Student Fee Remission	Overhead (10%)	Total Cost	
Jan-Dec	Task 1	522	\$8,804	\$1,645	\$1,000				\$4,314	\$3,144	\$15,763	
	Subtask 1a	131	\$2,201	\$411							\$2,612	
	Subtask 1b	131	\$2,201	\$411							\$2,612	
	Subtask 1c	522	\$8,804	\$1,645							\$10,449	
	Task 2	522	\$8,804	\$1,645	\$1,000			\$89,000		\$12,663	\$100,449	
	Subtask 2a	261	\$4,402	\$843							\$5,245	
	Subtask 2b	522	\$8,804	\$1,685							\$10,489	
	Subtask 2c	522	\$8,804	\$1,645							\$10,449	
	Project Management	208									\$0	
Total Cost Year 1: 2001			\$52,824	\$9,933	\$2,000	\$0	\$0	\$89,000	\$4,314	\$15,807	\$158,071	
Jan-Dec	Task 1	783	\$13,347	\$2,470					\$4,400	\$32,510	\$20,217	
	Subtask 1a	261	\$4,449	\$844							\$5,293	
	Subtask 1b	522	\$8,898	\$1,688							\$10,586	
	Subtask 1c	1566	\$26,693	\$4,940							\$31,633	
	Project Management	208									\$0	
Total Cost Year 2: 2002			\$53,387	\$9,942	\$0	\$0	\$0	\$0	\$4,400	\$32,510	\$67,729	
Jan-Dec	Task 1	1566	\$28,572	\$5,340					\$4,488	\$8,910	\$38,400	
	Task 2	1566	\$28,572	\$21,128	\$1,000						\$50,700	
	Project Management	208									\$0	
Total Cost Year 3: 2003			\$57,144	\$26,467	\$1,000	\$0	\$0	\$0	\$4,488	\$8,910	\$89,100	
Total Project Cost			\$163,355	\$46,342	\$3,000	\$0	\$0	\$89,000	\$13,203	\$57,227	\$314,900	



## Environmental Compliance Checklist

All applicants must fill out this Environmental Compliance Checklist. Applications must contain answers to the following questions to be responsive and to be considered for funding. Failure to answer these questions and include them with the application will result in the application being considered nonresponsive and not considered for funding.

1. Do any of the actions included in the proposal require compliance with either the California Environmental Quality Act (CEQA), the National Environmental Policy Act (NEPA), or both?

\_\_\_\_\_  
YES

  X    
NO

2. If you answered yes to # 1, identify the lead governmental agency for CEQA/NEPA compliance.

\_\_\_\_\_  
Lead Agency

3. If you answered no to # 1, explain why CEQA/NEPA compliance is not required for the actions in the proposal.

This research proposes to utilize technologies of remote sensing and GIS to monitor and assess the ecosystem/water quality. The results of the research will facilitate the implementation of CEPA and NEPA. However, the research will not require compliance with the two laws.

4. If CEQA/NEPA compliance is required, describe how the project will comply with either or both of these laws. Describe where the project is in the compliance process and the expected date of completion.

5. Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal?

\_\_\_\_\_  
YES

  X    
NO

If yes, the applicant must attach written permission for access from the relevant property owner(s). Failure to include written permission for access may result in disqualification of the proposal during the review process. Research and monitoring field projects for which specific field locations have not been identified will be required to provide access needs and permission for access with 30 days of notification of approval.

6. Please indicate what permits or other approvals may be required for the activities contained in your proposal. Check all boxes that apply.

**LOCAL**

Conditional use permit	___
Variance	___
Subdivision Map Act approval	___
Grading permit	___
General plan amendment	___
Specific plan approval	___
Rezone	___
Williamson Act Contract	___
cancellation	___
Other _____	
(please specify)	
None required	<u>X</u>

**STATE**

CESA Compliance	___	(CDFG)
Streambed alteration permit	___	(CDFG)
CWA § 401 certification	<u>X</u>	(RWQCB)
Coastal development permit	___	(Coastal Commission/BCDC)
Reclamation Board approval	___	
Notification	___	(DPC, BCDC)
Other _____		
(please specify)		
None required	___	

**FEDERAL**

ESA Consultation	___	(USFWS)
Rivers & Harbors Act permit	___	(ACOE)
CWA § 404 permit	___	(ACOE)
Other _____		
(please specify)		
None required	<u>X</u>	

DPC = Delta Protection Commission  
 CWA = Clean Water Act  
 CESA = California Endangered Species Act  
 USFWS = U.S. Fish and Wildlife Service  
 ACOE = U.S. Army Corps of Engineers

ESA = Endangered Species Act  
 CDFG = California Department of Fish and Game  
 RWQCB = Regional Water Quality Control Board  
 BCDC = Bay Conservation and Development Comm.

## Land Use Checklist

All applicants must fill out this Land Use Checklist for their proposal. Applications must contain answers to the following questions to be responsive and to be considered for funding. Failure to answer these questions and include them with the application will result in the application being considered nonresponsive and not considered for funding.

1. Do the actions in the proposal involve physical changes to the land (i.e. grading, planting vegetation, or breaching levees) or restrictions in land use (i.e. conservation easement or placement of land in a wildlife refuge)?

\_\_\_\_\_  
YES

\_\_\_\_\_  
X  
NO

2. If NO to # 1, explain what type of actions are involved in the proposal (i.e., research only, planning only).

Research only.

3. If YES to # 1, what is the proposed land use change or restriction under the proposal?

4. If YES to # 1, is the land currently under a Williamson Act contract?

\_\_\_\_\_  
YES

\_\_\_\_\_  
NO

5. If YES to # 1, answer the following:

Current land use

Current zoning

Current general plan designation

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

6. If YES to #1, is the land classified as Prime Farmland, Farmland of Statewide Importance or Unique Farmland on the Department of Conservation Important Farmland Maps?

\_\_\_\_\_  
YES

\_\_\_\_\_  
NO

\_\_\_\_\_  
DON'T KNOW

7. If YES to # 1, how many acres of land will be subject to physical change or land use restrictions under the proposal?

\_\_\_\_\_

8. If YES to # 1, is the property currently being commercially farmed or grazed?

\_\_\_\_\_  
YES

\_\_\_\_\_  
NO

9. If YES to #8, what are

the number of employees/acre \_\_\_\_\_

the total number of employees \_\_\_\_\_

10. Will the applicant acquire any interest in land under the proposal (fee title or a conservation easement)?

YES

NO

11. What entity/organization will hold the interest? \_\_\_\_\_

**12. If YES to # 10, answer the following:**

**Total number of acres to be acquired under proposal**

Number of acres to be acquired in fee

Number of acres to be subject to conservation easement

13. For all proposals involving physical changes to the land or restriction in land use, describe what entity or organization will:

**manage the property**

**provide operations and maintenance services**

**conduct monitoring**

14. For land acquisitions (fee title or easements), will existing water rights also be acquired?

**YES**

X  
NO

**15. Does the applicant propose any modifications to the water right or change in the delivery of the water?**

**YES**

NO

16. If YES to # 15, describe \_\_\_\_\_



smdowdy@ucdavis.edu  
OFFICE OF THE VICE CHANCELLOR FOR RESEARCH  
(530) 752-2075  
FAX: (530) 752-5432

410 Mrak Hall, One Shields Avenue  
DAVIS, CALIFORNIA 95616-8671

CALFED Bay-Delta Program Office  
1416 Ninth Street, Suite 1155  
Sacramento, CA 95814

Dear Colleague:

**2001 Proposal Solicitation**

Proposal Entitled "Monitoring and assessing the ecosystem/water quality in the San Francisco/  
Sacramento-San Joaquin bay-delta-valley region using remote sensing and GIS techniques"  
Principal Investigator: Minghua Zhang

It is a pleasure to present for your consideration the referenced proposal.

Following the direction of "**Attachment D - Terms and Conditions for State Proposition 204 Funds**", this is to provide notification that the applicant takes exception to the following proposed "standard" clauses:

Section 6. Substitution  
Section 9. Rights in Data  
Section 11. Indemnification, and  
Standard Clauses-Insurance Requirements - DWR

In order to bring the above provisions into conformity with the University of California Policy, we reserve the right to discuss with the aim of properly modifying these sections, should this proposal result in a subsequent award.

Please contact the principal investigator for scientific information. Administrative questions may be directed to my assistant, Ms. Petrina Ho, or me by telephone, facsimile or electronic mail at the numbers cited above. Furthermore, correspondence pertaining to this proposal and any subsequent award should be sent to the Office of Research and to the principal investigator.

Sincerely,

A handwritten signature in cursive script, appearing to read 'Sandra M. Dowdy', written over a horizontal line.  
Sandra M. Dowdy  
Contracts & Grants Analyst

Enclosures  
Cc: M. Zhang

# NONDISCRIMINATION COMPLIANCE STATEMENT

STD. 19 (REV. 3-95)

COMPANY NAME

The company named above (hereinafter referred to as "prospective contractor") hereby certifies, unless specifically exempted, compliance with Government Code Section 12990 (a-f) and California Code of Regulations, Title 2, Division 4, Chapter 5 in matters relating to reporting requirements and the development, implementation and maintenance of a Nondiscrimination Program. Prospective contractor agrees not to unlawfully discriminate, harass or allow harassment against any employee or applicant for employment because of sex, race, color, ancestry, religious creed, national origin, physical disability (including HIV and AIDS), medical condition (cancer), age (over 40), marital status, denial of family care leave and denial of pregnancy disability leave.

## CERTIFICATION

*I, the official named below, hereby swear that I am duly authorized to legally bind the prospective contractor to the above described certification. I am fully aware that this certification, executed on the date and in the county below, is made under penalty of perjury under the laws of the State of California.*

OFFICIAL'S NAME

THE REGENTS OF THE UNIVERSITY  
OF CALIFORNIA

DATE EXECUTED

*Sandra M. Dowdy* MAY 12 2000

PROSPECTIVE CONTRACTOR'S SIGNATURE

EXECUTED IN THE COUNTY OF

YOLO

PROSPECTIVE CONTRACTOR'S TITLE

Sandra M. Dowdy  
Contracts and Grants Analyst

PROSPECTIVE CONTRACTOR'S LEGAL BUSINESS NAME

U.S. Department of the Interior

**Certifications Regarding Debarment, Suspension and  
Other Responsibility Matters, Drug-Free Workplace  
Requirements and Lobbying**

Persons signing this form should refer to the regulations referenced below for complete instructions:

Certification Regarding Debarment, Suspension, and Other Responsibility Matters - Primary Covered Transactions - The prospective primary participant further agrees by submitting this proposal that it will include the clause titled, "Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion - Lower Tier Covered Transaction," provided by the department or agency entering into this covered transaction, without modification, in all lower tier covered transactions and in all solicitations for lower tier covered transactions. See below for language to be used; use this form for certification and sign; or use Department of the Interior Form 1954 (DI-1954). (See Appendix A of Subpart D of 43 CFR Part 12.)

Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion - Lower Tier Covered Transactions - (See Appendix B of Subpart D of 43 CFR Part 12.)

Certification Regarding Drug-Free Workplace Requirements - Alternate I. (Grantees Other Than Individuals) and Alternate II. (Grantees Who are Individuals) - (See Appendix C of Subpart D of 43 CFR Part 12.)

Signature on this form provides for compliance with certification requirements under 43 CFR Parts 12 and 18. The certifications shall be treated as a material representation of fact upon which reliance will be placed when the Department of the Interior determines to award the covered transaction, grant, cooperative agreement or loan.

---

**PART A: Certification Regarding Debarment, Suspension, and Other Responsibility Matters -  
Primary Covered Transactions**

---

*CHECK ☐ IF THIS CERTIFICATION IS FOR A PRIMARY COVERED TRANSACTION AND IS APPLICABLE.*

- (1) The prospective primary participant certifies to the best of its knowledge and belief, that it and its principals:
  - (a) Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency;
  - (b) Have not within a three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property;
  - (c) Are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State or local) with commission of any of the offenses enumerated in paragraph (1)(b) of this certification; and
  - (d) Have not within a three-year period preceding this application/proposal had one or more public transactions (Federal, State or local) terminated for cause or default.
- (2) Where the prospective primary participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

---

**PART B: Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion -  
Lower Tier Covered Transactions**

---

*CHECK ☐ IF THIS CERTIFICATION IS FOR A LOWER TIER COVERED TRANSACTION AND IS APPLICABLE.*

- (1) The prospective lower tier participant certifies, by submission of this proposal, that neither it nor its principals is presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participation in this transaction by any Federal department or agency.
- (2) Where the prospective lower tier participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

**PART C: Certification Regarding Drug-Free Workplace Requirements**

CHECK ☐ IF THIS CERTIFICATION IS FOR AN APPLICANT WHO IS NOT AN INDIVIDUAL

Alternate I. (Grantees Other Than Individuals)

A. The grantee certifies that it will or continue to provide a drug-free workplace by:

- (a) Publishing a statement notifying employees that the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance is prohibited in the grantee's workplace and specifying the actions that will be taken against employees for violation of such prohibition;
- (b) Establishing an ongoing drug-free awareness program to inform employees about—
  - (1) The dangers of drug abuse in the workplace;
  - (2) The grantee's policy of maintaining a drug-free workplace;
  - (3) Any available drug counseling, rehabilitation, and employee assistance programs; and
  - (4) The penalties that may be imposed upon employees for drug abuse violations occurring in the workplace;
- (c) Making it a requirement that each employee to be engaged in the performance of the grant be given a copy of the statement required by paragraph (a);
- (d) Notifying the employee in the statement required by paragraph (a) that, as a condition of employment under the grant, the employee will —
  - (1) Abide by the terms of the statement; and
  - (2) Notify the employer in writing of his or her conviction for a violation of a criminal drug statute occurring in the workplace no later than five calendar days after such conviction;
- (e) Notifying the agency in writing, within ten calendar days after receiving notice under subparagraph (d)(2) from an employee or otherwise receiving actual notice of such conviction. Employers of convicted employees must provide notice, including position title, to every grant officer on whose grant activity the convicted employee was working, unless the Federal agency has designated a central point for the receipt of such notices. Notice shall include the identification number(s) of each affected grant;
- (f) Taking one of the following actions, within 30 calendar days of receiving notice under subparagraph (d)(2), with respect to any employee who is so convicted —
  - (1) Taking appropriate personnel action against such an employee, up to and including termination, consistent with the requirements of the Rehabilitation Act of 1973, as amended; or
  - (2) Requiring such employee to participate satisfactorily in a drug abuse assistance or rehabilitation program approved for such purposes by a Federal, State, or local health, law enforcement, or other appropriate agency;
- (g) Making a good faith effort to continue to maintain a drug-free workplace through implementation of paragraphs (a), (b), (c), (d), (e) and (f).

B. The grantee may insert in the space provided below the site(s) for the performance of work done in connection with the specific grant:

Place of Performance (Street address, city, county, state, zip code)

Check ☐ if there are workplaces on file that are not identified here.

**PART D: Certification Regarding Drug-Free Workplace Requirements**

CHECK ☐ IF THIS CERTIFICATION IS FOR AN APPLICANT WHO IS AN INDIVIDUAL

Alternate II. (Grantees Who Are Individuals)

- (a) The grantee certifies that, as a condition of the grant, he or she will not engage in the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance in conducting any activity with the grant;
- (b) If convicted of a criminal drug offense resulting from a violation occurring during the conduct of any grant activity, he or she will report the conviction, in writing, within 10 calendar days of the conviction, to the grant officer or other designee, unless the Federal agency designates a central point for the receipt of such notices. When notice is made to such a central point, it shall include the identification number(s) of each affected grant.



**PART E:** Certification Regarding Lobbying  
Certification for Contracts, Grants, Loans, and Cooperative Agreements

CHECK ☐ IF CERTIFICATION IS FOR THE AWARD OF ANY OF THE FOLLOWING AND  
THE AMOUNT EXCEEDS \$100,000: A FEDERAL GRANT OR COOPERATIVE AGREEMENT,  
SUBCONTRACT, OR SUBGRANT UNDER THE GRANT OR COOPERATIVE AGREEMENT.

CHECK ☐ IF CERTIFICATION IS FOR THE AWARD OF A FEDERAL  
LOAN EXCEEDING THE AMOUNT OF \$150,000, OR A SUBGRANT OR  
SUBCONTRACT EXCEEDING \$100,000, UNDER THE LOAN.

The undersigned certifies, to the best of his or her knowledge and belief, that:

- (1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, and officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
- (2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.
- (3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than \$10,000 and not more than \$100,000 for each such failure.

As the authorized certifying official, I hereby certify that the above specified certifications are true.

SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL

*Sandra M. Dowdy*

TYPED NAME AND TITLE

Sandra M. Dowdy  
Contracts and Grants Analyst

DATE

MAY 12 2000

**APPLICATION FOR  
FEDERAL ASSISTANCE**

<b>1. TYPE OF SUBMISSION:</b> <i>Application</i> <input type="checkbox"/> Construction <input type="checkbox"/> Construction <input checked="" type="checkbox"/> Non-Construction <input type="checkbox"/> Non-Construction		<b>2. DATE SUBMITTED</b>		Application Identifier /																									
		<b>3. DATE RECEIVED BY STATE</b>		State Application Identifier																									
		<b>4. DATE RECEIVED BY FEDERAL AGENCY</b>		Federal Identifier																									
<b>5. APPLICATION INFORMATION</b>																													
<b>Legal Name</b> The Regents of the University of California			<b>Organizational Unit</b> Land, Air and Water Resources																										
<b>Address (give city, county, state, and zip code)</b> Office of the Vice Chancellor of Research 410 Mrak Hall University of California Davis, California 95616-8671 <b>YOLO COUNTY</b>			<b>Name and telephone number of the person to be contacted on matters involving this application (give area code)</b> <table style="width:100%;"> <tr> <td style="width:50%; vertical-align: top;"> <b>Administrative Contact</b>            Sandra Dowdy            (530) 754-6131         </td> <td style="width:50%; vertical-align: top;"> <b>Technical Contact</b>            Minghua Zhang            (530) 752-4953         </td> </tr> </table>			<b>Administrative Contact</b> Sandra Dowdy (530) 754-6131	<b>Technical Contact</b> Minghua Zhang (530) 752-4953																						
<b>Administrative Contact</b> Sandra Dowdy (530) 754-6131	<b>Technical Contact</b> Minghua Zhang (530) 752-4953																												
<b>6. EMPLOYER IDENTIFICATION NUMBER (EIN):</b> <table style="width:100%; text-align: center;"> <tr> <td style="border: 1px solid black; width: 20px;">9</td> <td style="border: 1px solid black; width: 20px;">4</td> <td style="border: 1px solid black; width: 20px;">—</td> <td style="border: 1px solid black; width: 20px;">6</td> <td style="border: 1px solid black; width: 20px;">0</td> <td style="border: 1px solid black; width: 20px;">3</td> <td style="border: 1px solid black; width: 20px;">6</td> <td style="border: 1px solid black; width: 20px;">4</td> <td style="border: 1px solid black; width: 20px;">9</td> <td style="border: 1px solid black; width: 20px;">4</td> </tr> </table>			9	4	—	6	0	3	6	4	9	4	<b>7. TYPE OF APPLICANT: (enter appropriate letter in box)</b> <span style="border: 1px solid black; padding: 0 5px;">I</span> <table style="width:100%;"> <tr> <td style="width:50%;">A. State</td> <td style="width:50%;">H. Independent School Dist.</td> </tr> <tr> <td>B. County</td> <td>I. State Controlled Institution of Higher Learning</td> </tr> <tr> <td>C. Municipal</td> <td>J. Private University</td> </tr> <tr> <td>D. Township</td> <td>K. Indian Tribe</td> </tr> <tr> <td>E. Interstate</td> <td>L. Individual</td> </tr> <tr> <td>F. Intermunicipal</td> <td>M. Profit Organization</td> </tr> <tr> <td>G. Special District</td> <td>N. Other (Specify): _____</td> </tr> </table>			A. State	H. Independent School Dist.	B. County	I. State Controlled Institution of Higher Learning	C. Municipal	J. Private University	D. Township	K. Indian Tribe	E. Interstate	L. Individual	F. Intermunicipal	M. Profit Organization	G. Special District	N. Other (Specify): _____
9	4	—	6	0	3	6	4	9	4																				
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G. Special District	N. Other (Specify): _____																												
<b>8. TYPE OF APPLICATION:</b> <input checked="" type="checkbox"/> New <input type="checkbox"/> Continuation <input type="checkbox"/> Revision If Revision, enter appropriate letter(s) in boxes(es) <span style="border: 1px solid black; width: 20px; height: 15px; display: inline-block;"></span> <span style="border: 1px solid black; width: 20px; height: 15px; display: inline-block;"></span> A. Increase Award      B. Decrease Award      C. Increase Duration D. Decrease Duration      Other (specify): _____			<b>9. NAME OF FEDERAL AGENCY:</b> CALFED Bay-Delta Program																										
<b>10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER:</b> <span style="border: 1px solid black; width: 20px; height: 15px; display: inline-block;"></span> <span style="border: 1px solid black; width: 20px; height: 15px; display: inline-block;"></span> <span style="border: 1px solid black; width: 20px; height: 15px; display: inline-block;"></span> <span style="border: 1px solid black; width: 20px; height: 15px; display: inline-block;"></span> <span style="border: 1px solid black; width: 20px; height: 15px; display: inline-block;"></span> <b>TITLE:</b>			<b>11. DESCRIPTIVE TITLE OF APPLICANT'S PROJECT:</b> Monitoring and assessing the ecosystem/water quality in the San Francisco/Sacramento-San Joaquin bay-delta-valley region using remote sensing and GIS techniques																										
<b>12. AREAS AFFECTED BY PROJECT (cities, counties, states, etc.)</b> Sacramento and San Joaquin counties																													
<b>13. PROPOSED PROJECT:</b> <table style="width:100%;"> <tr> <td style="width:50%;">Start Date 10/01/00</td> <td style="width:50%;">Ending Date 09/30/03</td> </tr> </table>		Start Date 10/01/00	Ending Date 09/30/03	<b>14. CONGRESSIONAL DISTRICTS OF:</b> <table style="width:100%;"> <tr> <td style="width:50%;">a. Applicant 3rd</td> <td style="width:50%;">b. Project</td> </tr> </table>				a. Applicant 3rd	b. Project																				
Start Date 10/01/00	Ending Date 09/30/03																												
a. Applicant 3rd	b. Project																												
<b>15. ESTIMATED FUNDING:</b> <table style="width:100%;"> <tr> <td style="width:30%;">a. Federal</td> <td style="width:70%;">\$ 416,446</td> </tr> <tr> <td>b. Applicant</td> <td>\$</td> </tr> <tr> <td>c. State</td> <td>\$</td> </tr> <tr> <td>d. Local</td> <td>\$</td> </tr> <tr> <td>e. Other</td> <td>\$</td> </tr> <tr> <td>f. Program Income</td> <td>\$</td> </tr> <tr> <td>g. TOTAL</td> <td>\$ 416,446</td> </tr> </table>		a. Federal	\$ 416,446	b. Applicant	\$	c. State	\$	d. Local	\$	e. Other	\$	f. Program Income	\$	g. TOTAL	\$ 416,446	<b>16. IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?</b> a. YES. THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON: DATE _____ b. NO. <input checked="" type="checkbox"/> PROGRAM IS NOT COVERED BY E.O. 12372 <input type="checkbox"/> OR PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW													
a. Federal	\$ 416,446																												
b. Applicant	\$																												
c. State	\$																												
d. Local	\$																												
e. Other	\$																												
f. Program Income	\$																												
g. TOTAL	\$ 416,446																												
<b>17. IS THE APPLICANT DELINQUENT ON ANY FEDERAL DEBT?</b> <input type="checkbox"/> Yes      If "Yes," attach an explanation. <input checked="" type="checkbox"/> No																													
<b>18. TO THE BEST OF MY KNOWLEDGE AND BELIEF, ALL DATA IN THIS APPLICATION/PREAPPLICATION ARE TRUE AND CORRECT THE DOCUMENT HAS BEEN DULY AUTHORIZED BY THE GOVERNING BODY OF THE APPLICANT AND THE APPLICANT WILL COMPLY WITH THE ATTACHED ASSURANCES IF THE ASSISTANCE IS AWARDED</b>																													
<b>a. Typed Name of Authorized Representative</b> Sandra Dowdy			<b>b. Title</b> Contracts & Grants Analyst		<b>c. Telephone number</b> (530) 754-6131																								
<b>d. Signature of Authorized Representative</b> 			<b>e. Date Signed</b> MAY 12 2000																										

# BUDGET INFORMATION - Non-Construction Programs

OMB Approval No.: 0348-0044

SECTION A - BUDGET SUMMARY									
Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds			New or Revised Budget			Total (g)	
		Federal (c)	Non - Federal (d)	Federal (e)	Non - Federal (f)	Federal (e)	Non - Federal (f)		
1. CALFED Bay-Delta		\$	\$	\$ 416,446.00	\$	\$ 416,446.00	\$	\$ 416,446.00	
2.								0.00	
3.								0.00	
4.								0.00	
5. Totals		\$ 0.00	\$ 0.00	\$ 416,446.00	\$ 0.00	\$ 416,446.00	\$ 0.00	\$ 416,446.00	
SECTION B - BUDGET CATEGORIES									
6. Object Class Categories		GRANT PROGRAM, FUNCTION OR ACTIVITY					Total		
		(1) 2000-2001	(2) 2001-2002	(3) 2002-2003	(4) 2002-2003	(4)	(5)	(5)	(5)
a. Personnel		\$ 52,824.00	\$ 53,387.00	\$ 57,144.00	\$	\$	\$	\$ 163,355.00	
b. Fringe Benefits		9,933.00	9,942.00	26,467.00				46,342.00	
c. Travel		2,000.00	0.00	1,000.00				3,000.00	
d. Equipment		89,000.00	0.00	0.00				89,000.00	
e. Supplies		0.00	0.00	0.00				0.00	
f. Contractual		0.00	0.00	0.00				0.00	
g. Construction		0.00	0.00	0.00				0.00	
h. Other		4,314.00	4,400.00	4,488.00				13,202.00	
i. Total Direct Charge (sum of 6a-6h)		158,071.00	67,729.00	89,099.00	0.00			314,899.00	
j. Indirect Charges		30,112.00	30,398.00	41,037.00				101,546.00	
k. TOTALS (sum of 6i and 6j)		\$ 188,183.00	\$ 98,127.00	\$ 130,136.00	\$ 0.00	\$	\$	\$ 416,445.00	
7. Program Income		\$	\$	\$	\$	\$	\$	\$	

Standard Form 424A (Rev. 4-92)  
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SECTION C - NON-FEDERAL RESOURCES					
(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e) TOTALS	
8. CALFED Bay-Delta Program	\$	\$	\$	\$	0.00
9.					0.00
10.					0.00
11.					0.00
12. TOTAL (sum of lines 8 - 11)	\$ 0.00	\$ 0.00	\$ 0.00	\$ 0.00	0.00
SECTION D - FORECASTED CASH NEEDS					
Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	
13. Federal	\$ 0.00	\$	\$	\$	
14. NonFederal	0.00				
15. TOTAL (sum of lines 13 and 14)	\$ 0.00	\$ 0.00	\$ 0.00	\$ 0.00	0.00
SECTION E - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE OF THE PROJECT					
(a) Grant Program	FUTURE FUNDING PERIODS (Years)				(e) Fourth
	(b) First	(c) Second	(d) Third		
16. CALFED Bay-Delta Program	\$ 188,182.00	\$ 98,127.00	\$ 130,136.00	\$	
17.					
18.					
19.					
20. TOTAL (sum of lines 16 - 19)	\$ 188,182.00	\$ 98,127.00	\$ 130,136.00	\$	0.00
SECTION F - OTHER BUDGET INFORMATION					
21. Direct Charges:		22. Indirect Charges:			
\$314,900		\$101,546			
23. Remarks:					

**ASSURANCES - NON-CONSTRUCTION PROGRAMS**

Public reporting burden for this collection of information is estimated to average 15 minutes per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Office of Management and Budget, Paperwork Reduction Project (0348-0040), Washington, DC 20503.

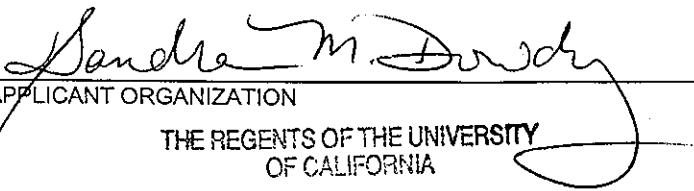
**PLEASE DO NOT RETURN YOUR COMPLETED FORM TO THE OFFICE OF MANAGEMENT AND BUDGET. SEND IT TO THE ADDRESS PROVIDED BY THE SPONSORING AGENCY.**

**NOTE:** Certain of these assurances may not be applicable to your project or program. If you have questions, please contact the awarding agency. Further, certain Federal awarding agencies may require applicants to certify to additional assurances. If such is the case, you will be notified.

As the duly authorized representative of the applicant, I certify that the applicant:

1. Has the legal authority to apply for Federal assistance and the institutional, managerial and financial capability (including funds sufficient to pay the non-Federal share of project cost) to ensure proper planning, management and completion of the project described in this application.
2. Will give the awarding agency, the Comptroller General of the United States and, if appropriate, the State, through any authorized representative, access to and the right to examine all records, books, papers, or documents related to the award; and will establish a proper accounting system in accordance with generally accepted accounting standards or agency directives.
3. Will establish safeguards to prohibit employees from using their positions for a purpose that constitutes or presents the appearance of personal or organizational conflict of interest, or personal gain.
4. Will initiate and complete the work within the applicable time frame after receipt of approval of the awarding agency.
5. Will comply with the Intergovernmental Personnel Act of 1970 (42 U.S.C. §§4728-4763) relating to prescribed standards for merit systems for programs funded under one of the 19 statutes or regulations specified in Appendix A of OPM's Standards for a Merit System of Personnel Administration (5 C.F.R. 900, Subpart F).
6. Will comply with all Federal statutes relating to nondiscrimination. These include but are not limited to: (a) Title VI of the Civil Rights Act of 1964 (P.L. 88-352) which prohibits discrimination on the basis of race, color or national origin; (b) Title IX of the Education Amendments of 1972, as amended (20 U.S.C. §§1681-1683, and 1685-1686), which prohibits discrimination on the basis of sex; (c) Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. §794), which prohibits discrimination on the basis of handicaps; (d) the Age Discrimination Act of 1975, as amended (42 U.S.C. §§6101-6107), which prohibits discrimination on the basis of age; (e) the Drug Abuse Office and Treatment Act of 1972 (P.L. 92-255), as amended, relating to nondiscrimination on the basis of drug abuse; (f) the Comprehensive Alcohol Abuse and Alcoholism Prevention, Treatment and Rehabilitation Act of 1970 (P.L. 91-616), as amended, relating to nondiscrimination on the basis of alcohol abuse or alcoholism; (g) §§523 and 527 of the Public Health Service Act of 1912 (42 U.S.C. §§290 dd-3 and 290 ee 3), as amended, relating to confidentiality of alcohol and drug abuse patient records; (h) Title VIII of the Civil Rights Act of 1968 (42 U.S.C. §§3601 et seq.), as amended, relating to nondiscrimination in the sale, rental or financing of housing; (i) any other nondiscrimination provisions in the specific statute(s) under which application for Federal assistance is being made; and, (j) the requirements of any other nondiscrimination statute(s) which may apply to the application.
7. Will comply, or has already complied, with the requirements of Titles II and III of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646) which provide for fair and equitable treatment of persons displaced or whose property is acquired as a result of Federal or federally-assisted programs. These requirements apply to all interests in real property acquired for project purposes regardless of Federal participation in purchases.
8. Will comply, as applicable, with provisions of the Hatch Act (5 U.S.C. §§1501-1508 and 7324-7328) which limit the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.

9. Will comply, as applicable, with the provisions of the Davis-Bacon Act (40 U.S.C. §§276a to 276a-7), the Copeland Act (40 U.S.C. §276c and 18 U.S.C. §874), and the Contract Work Hours and Safety Standards Act (40 U.S.C. §§327-333), regarding labor standards for federally-assisted construction subagreements.
10. Will comply, if applicable, with flood insurance purchase requirements of Section 102(a) of the Flood Disaster Protection Act of 1973 (P.L. 93-234) which requires recipients in a special flood hazard area to participate in the program and to purchase flood insurance if the total cost of insurable construction and acquisition is \$10,000 or more.
11. Will comply with environmental standards which may be prescribed pursuant to the following: (a) institution of environmental quality control measures under the National Environmental Policy Act of 1969 (P.L. 91-190) and Executive Order (EO) 11514; (b) notification of violating facilities pursuant to EO 11738; (c) protection of wetlands pursuant to EO 11990; (d) evaluation of flood hazards in floodplains in accordance with EO 11988; (e) assurance of project consistency with the approved State management program developed under the Coastal Zone Management Act of 1972 (16 U.S.C. §§1451 et seq.); (f) conformity of Federal actions to State (Clean Air) Implementation Plans under Section 176(c) of the Clean Air Act of 1955, as amended (42 U.S.C. §§7401 et seq.); (g) protection of underground sources of drinking water under the Safe Drinking Water Act of 1974, as amended (P.L. 93-523); and, (h) protection of endangered species under the Endangered Species Act of 1973, as amended (P.L. 93-205).
12. Will comply with the Wild and Scenic Rivers Act of 1968 (16 U.S.C. §§1271 et seq.) related to protecting components or potential components of the national wild and scenic rivers system.
13. Will assist the awarding agency in assuring compliance with Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. §470), EO 11593 (identification and protection of historic properties), and the Archaeological and Historic Preservation Act of 1974 (16 U.S.C. §§469a-1 et seq.).
14. Will comply with P.L. 93-348 regarding the protection of human subjects involved in research, development, and related activities supported by this award of assistance.
15. Will comply with the Laboratory Animal Welfare Act of 1966 (P.L. 89-544, as amended, 7 U.S.C. §§2131 et seq.) pertaining to the care, handling, and treatment of warm blooded animals held for research, teaching, or other activities supported by this award of assistance.
16. Will comply with the Lead-Based Paint Poisoning Prevention Act (42 U.S.C. §§4801 et seq.) which prohibits the use of lead-based paint in construction or rehabilitation of residence structures.
17. Will cause to be performed the required financial and compliance audits in accordance with the Single Audit Act Amendments of 1996 and OMB Circular No. A-133, "Audits of States, Local Governments, and Non-Profit Organizations."
18. Will comply with all applicable requirements of all other Federal laws, executive orders, regulations, and policies governing this program.

SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL 	TITLE Sandra M. Dowdy Contracts and Grants Analyst
APPLICANT ORGANIZATION THE REGENTS OF THE UNIVERSITY OF CALIFORNIA	DATE SUBMITTED MAY 12 2000